

# Neutrino flavor evolution in dense astrophysical sources

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VILLUM FONDEN



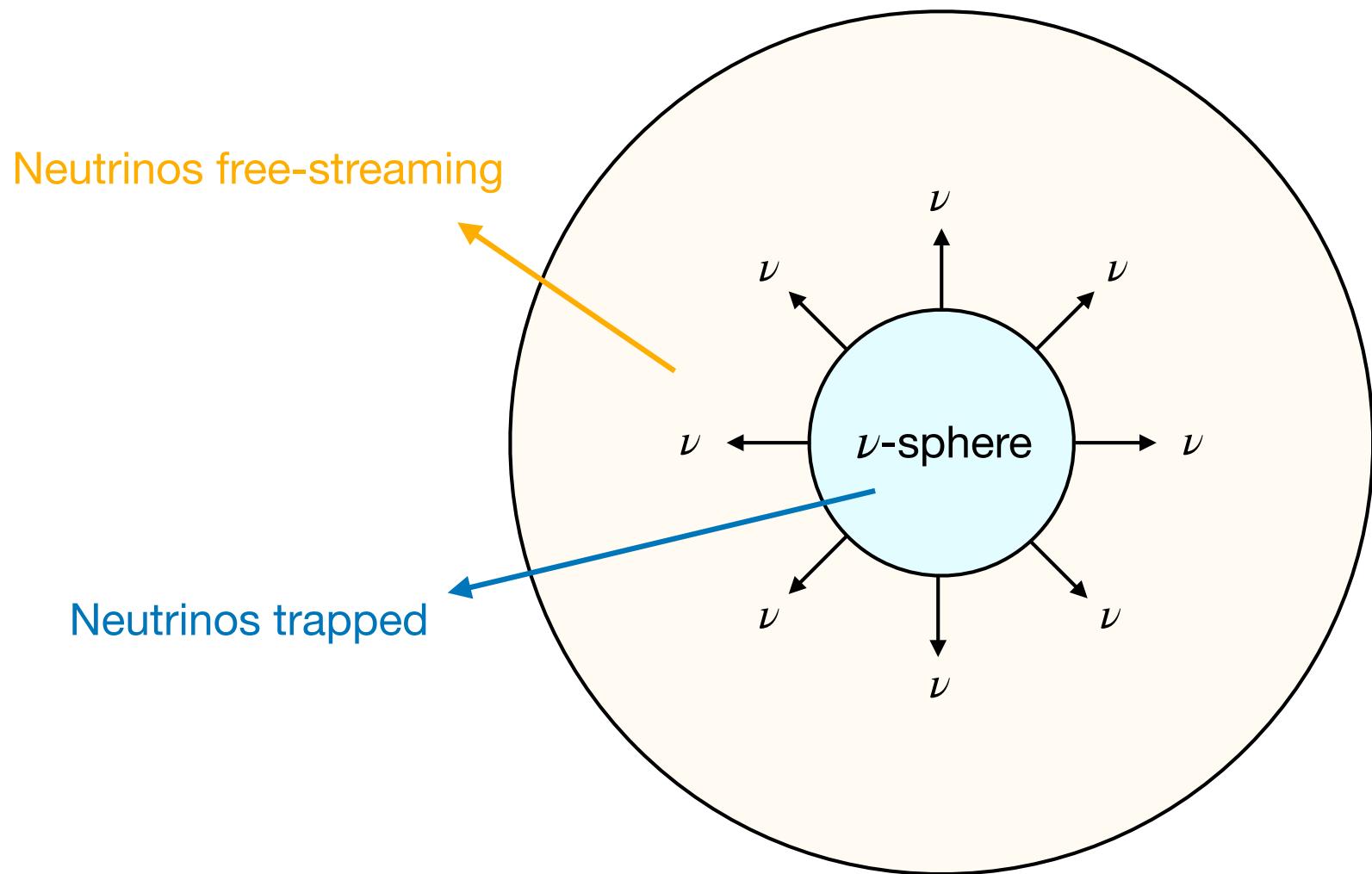
# Outline

- Neutrino decoupling in dense media
- Neutrino equations of motion
- Neutrino flavor evolution without periodic boundaries
- Neutrino flavor evolution with periodic boundaries

This talk is based on:

**Marie Cornelius**, Shashank Shalgar & Irene Tamborra (to appear soon)

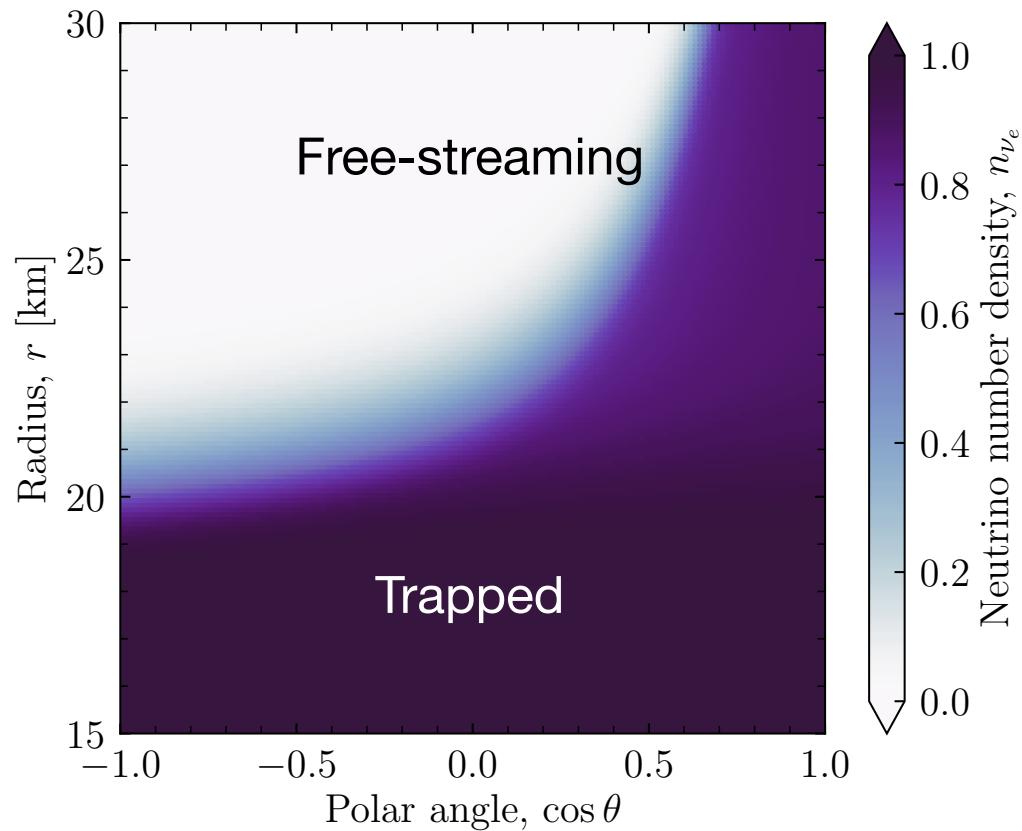
# Neutrino decoupling in the supernova core



Neutrinos are initially trapped and then start to free-stream

# Neutrino decoupling in the supernova core

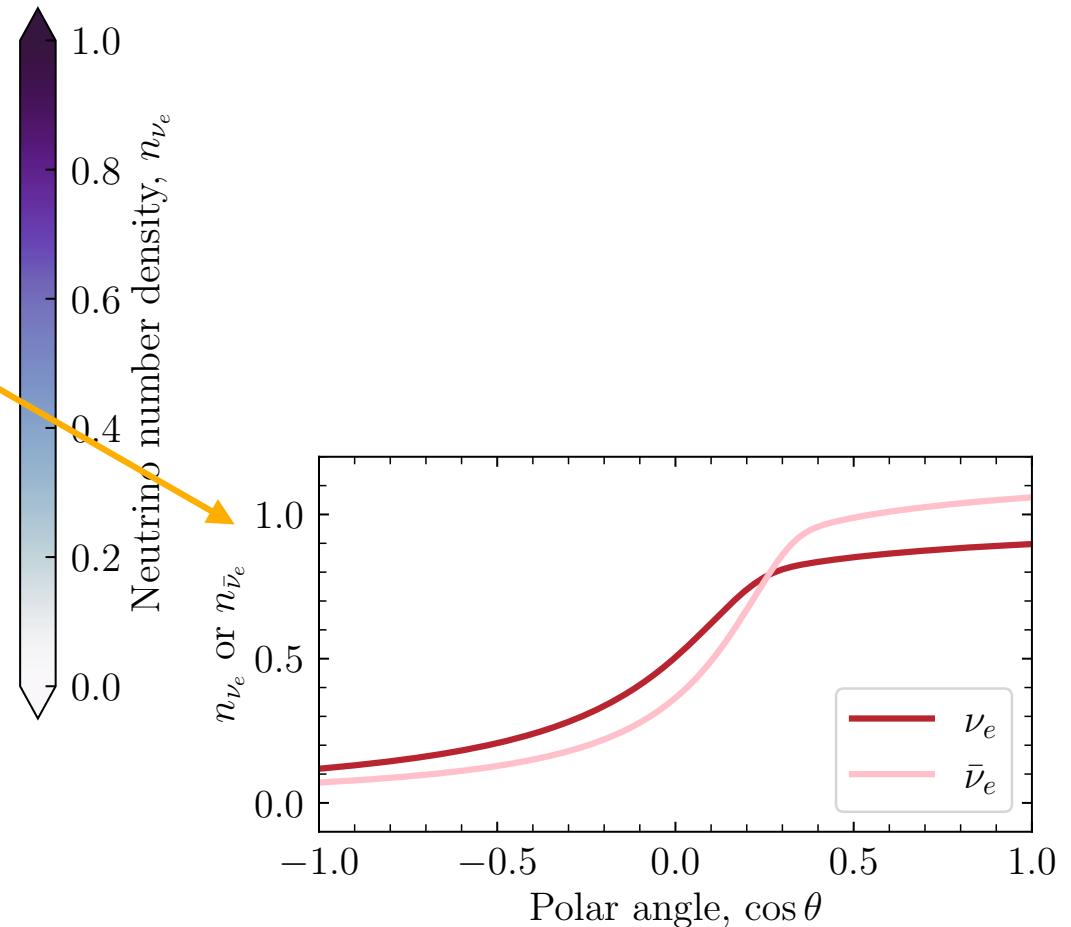
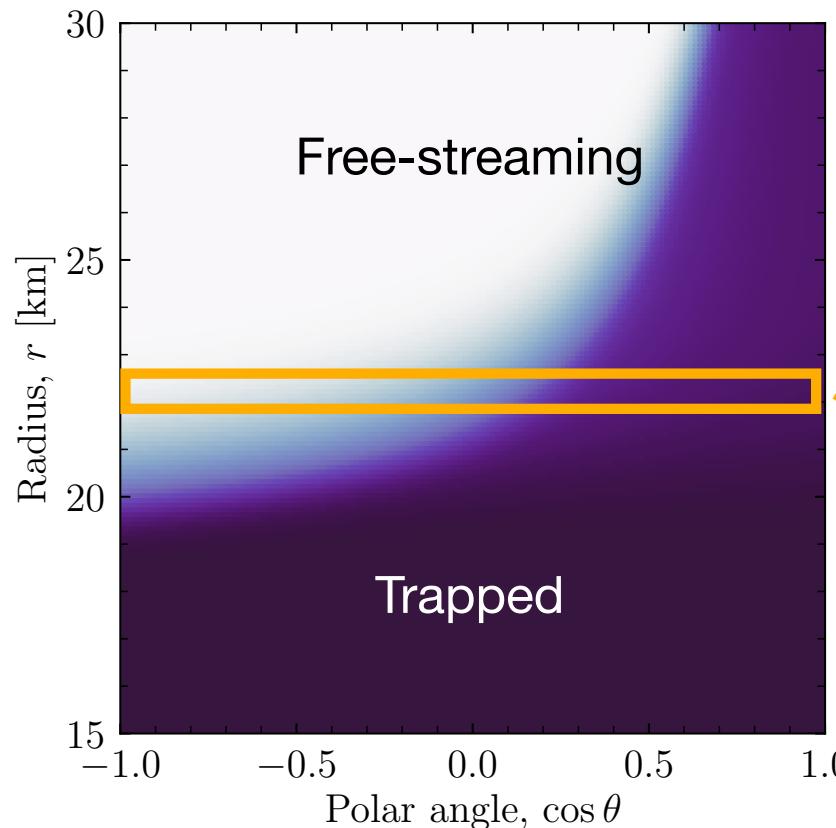
## without flavor conversions



Due to collisions, neutrinos decouple from matter

# Neutrino decoupling in the supernova core

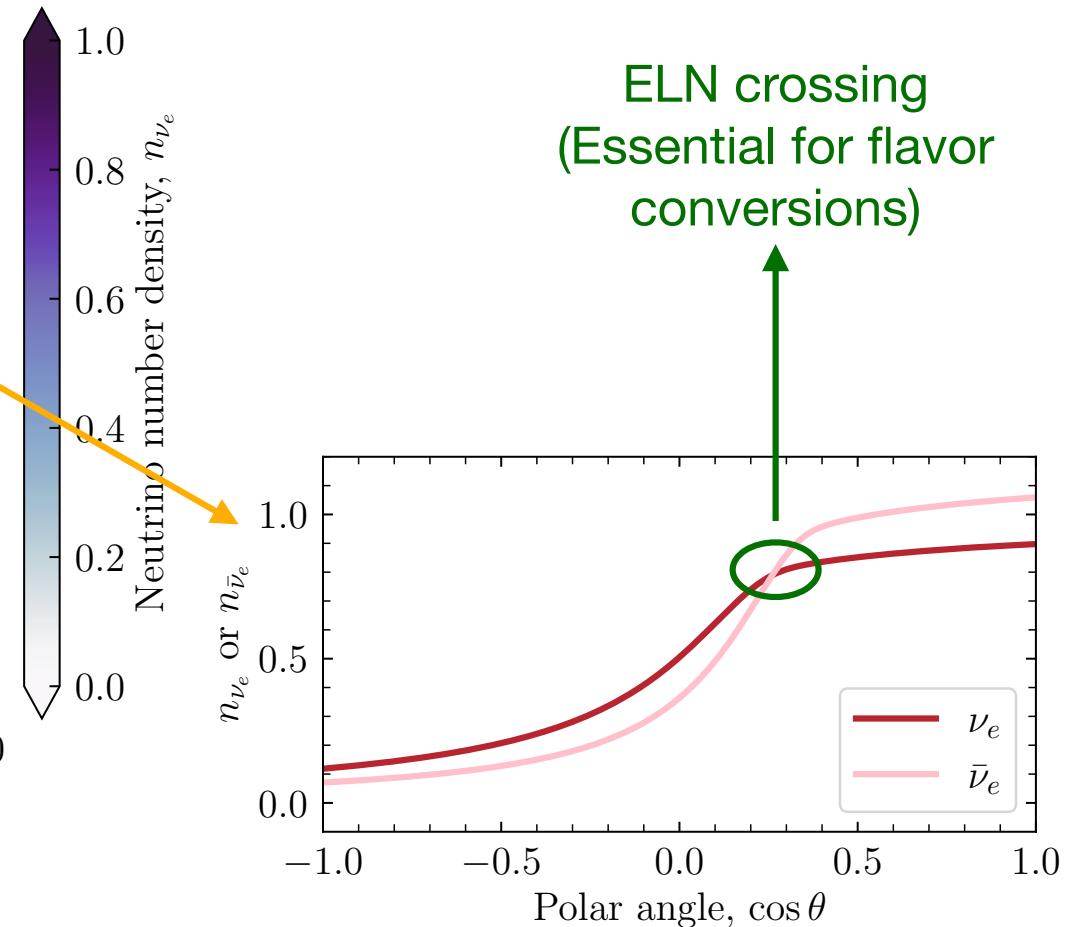
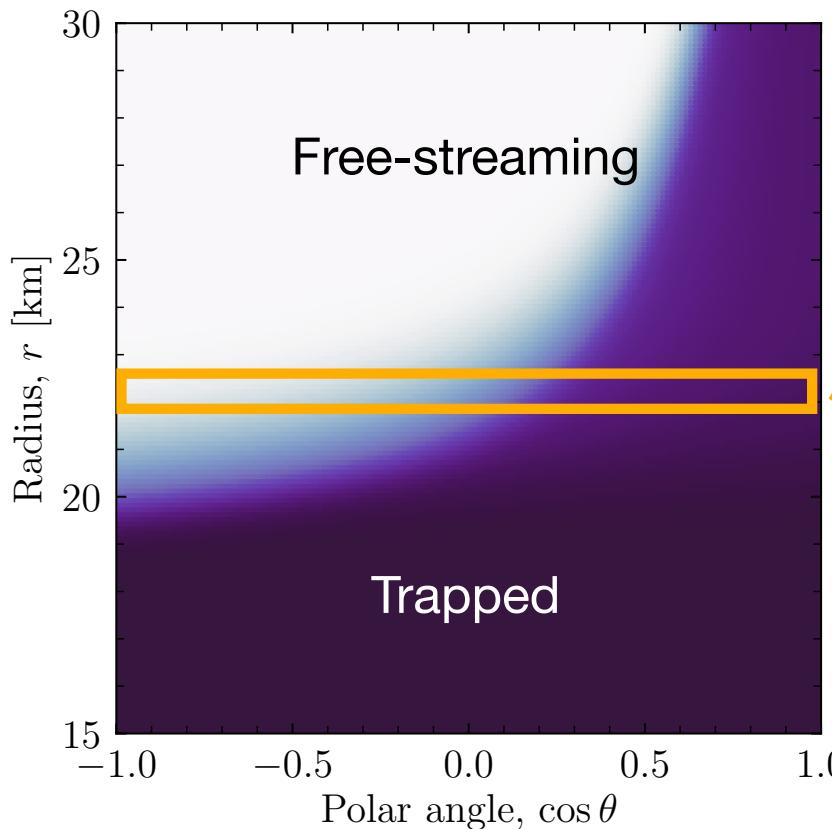
## without flavor conversions



Due to collisions, neutrinos decouple from matter

# Neutrino decoupling in the supernova core

## without flavor conversions



Due to collisions, neutrinos decouple from matter

# Neutrino equations of motion

$$i \left( \frac{\partial}{\partial t} + \vec{v} \cdot \nabla \right) \rho(r, \cos \theta, t) = [H, \rho(r, \cos \theta, t)] + i\mathcal{C}$$

Advection

Density matrix

Flavor conversions

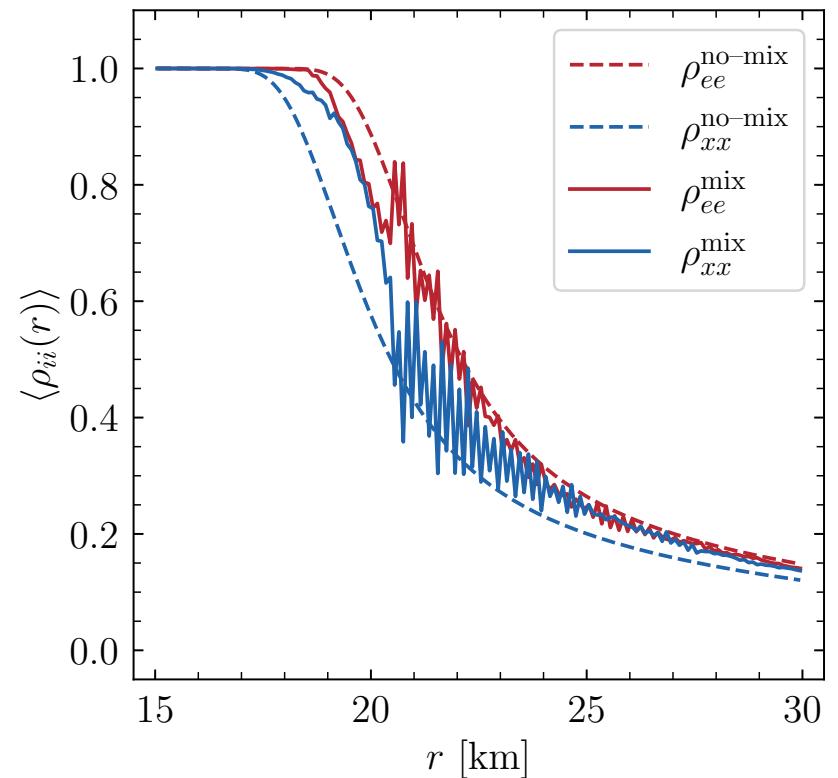
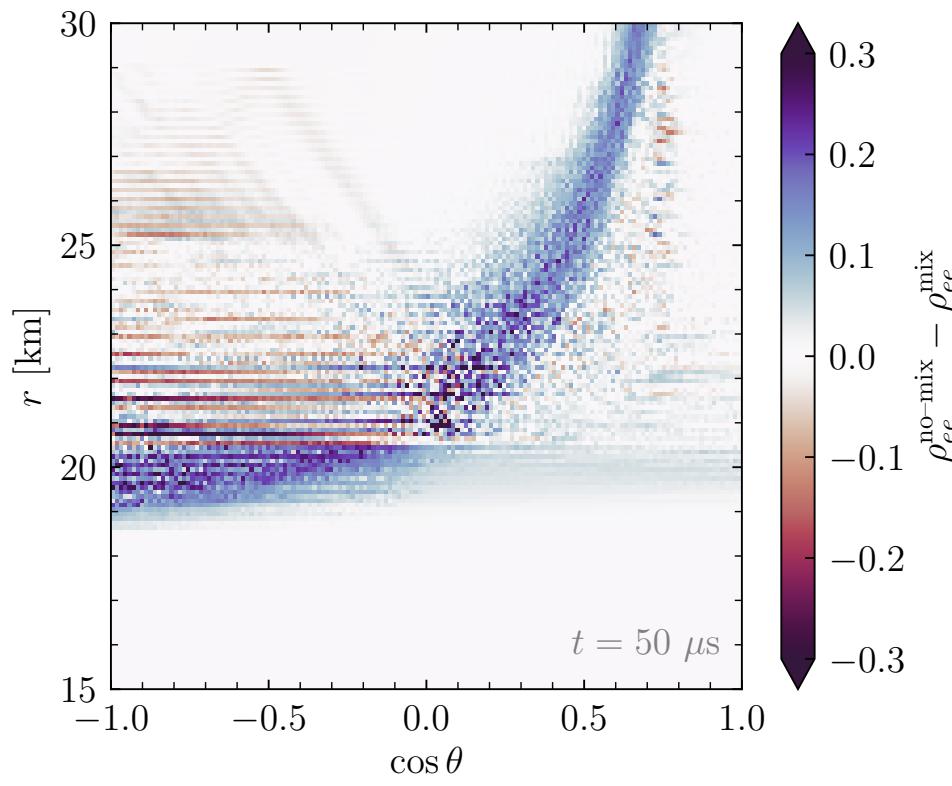
Collisions between neutrinos and matter

$$H = H_{\text{vacuum}} + H_{\text{matter}} + H_{\nu\nu}$$

Because of the large density of neutrinos, neutrino-neutrino interactions are crucial for flavor conversions in the core of a supernova

# Neutrino decoupling in the supernova core

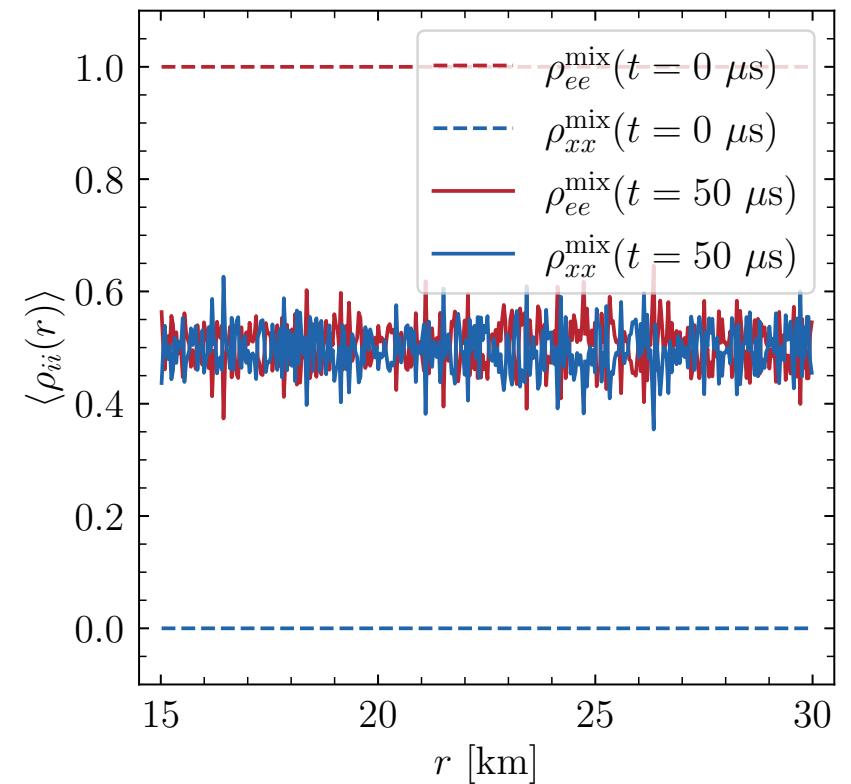
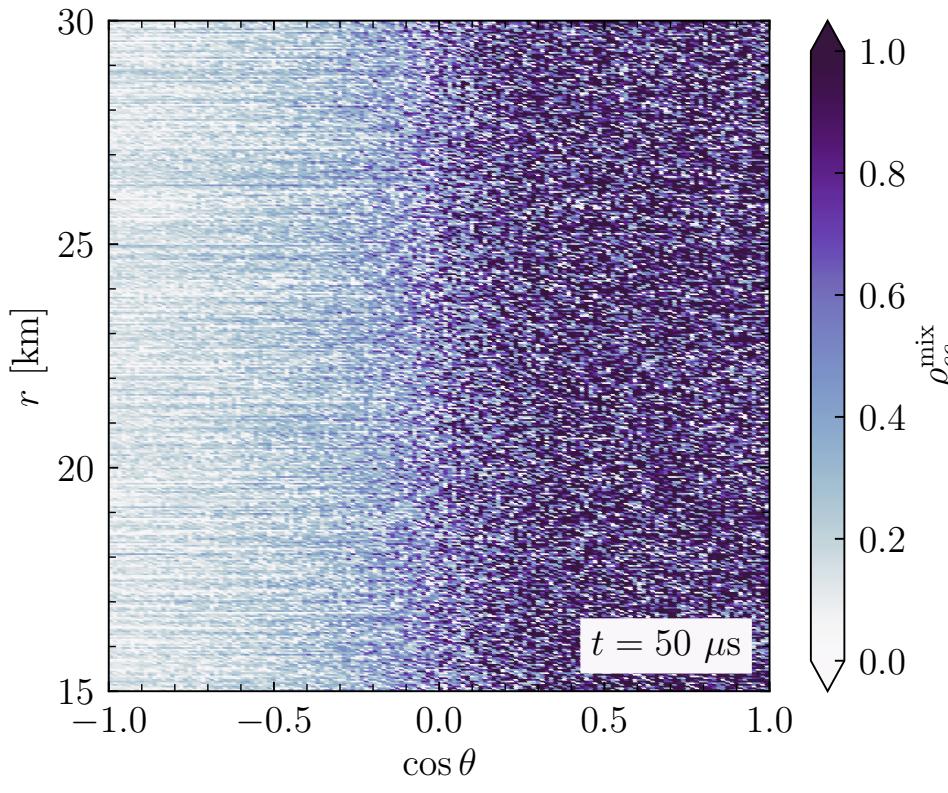
**with flavor conversions** and **without periodic boundaries**



Neutrinos change flavor during decoupling in the proximity of ELN crossings

# Neutrino decoupling in the supernova core

**with flavor conversions** and **with periodic boundaries**



Neutrino flavor conversion is strongly affected by the choice of simulation boundaries  $\implies$  Periodic boundaries lead to flavor equipartition

# Conclusions

- Because of neutrino-neutrino interactions, neutrinos change flavor in the decoupling region
- Flavor equipartition is not a general conclusion but it depends on the choice of the boundaries

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Thank you!